Construction and Ice Quality

Juan Pablo Yanez

for the IceCube Collaboration

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j.p.yanez@ualberta.ca





Why the South Pole?

- A lot of deep, clear ice
 - Thick glacier
 - No light pollution
 - Effectively static
- Logistic support
 - All airlifted



http://www.antarcticglaciers.org

Transport and logistics

- Construction work only in summer: December February
- Passengers and cargo transported in LC-130s
- 2.1 million kilograms of cargo for the project



Deployment - Drilling with hot water

- 5 MW Drill power plant \rightarrow water @ 90°C in closed loop
- 21,000 liters of jet fuel / hole
- 30 man crew
- 30 h drilling 3 day cycle time
- Hole lifetime: 24h
- DOM installation: 8h
- Freezeback time: a few weeks



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The IceCube drill



Construction timeline



Construction timeline

First hole took weeks to drill

Time went down to 30h/hole by end of construction



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The last DOM deployed





Light in glacial ice



Glacial ice

- Optical scattering & absorption impact physics
- Ice properties mapped by dust logger, ice cores and in-situ LED flashers





Layered structure

- Good modeling with flashers
- Layered structure visible





Comparison of dust logger and flasher scattering

Tilted layers

• The ice surface is flat and smooth, but the bedrock has features



Tilted layers

• Terrain imprints itself on ice





Rivers of ice

- Ice is flowing
- Stresses impact crystal structure and impurities, thus optical properties



Rivers of ice

• Geographic South Pole marker needs to be moved 10m every season



Anisotropy – a result from the flow

- Light attenuation has a direction dependence
 - Less attenuation along flow direction



The ice in the hole

• Drill \rightarrow Deploy \rightarrow Wait





Pristine glacial ice here

Not so pristine glacial ice here

Drill could have introduced impurities and gas (bubbles)

The ice in the hole

• Drill \rightarrow Deploy \rightarrow Wait





https://icecube.wisc.edu/~mrongen/IceCube-camerafreeze-in-22-Dec-1st-January-2011.m4v

The POCAM device and hole ice





Calibration sources

CCD^[2]

Piezo-module^[1]





CMOS^[2]



POCAM^[3]



[1] https://doi.org/10.1051/epjconf/201713506003
[2] https://doi.org/10.22323/1.301.1040
[3] https://doi.org/10.22323/1.301.0934

Summary

- Constructing IceCube was an enormous endeavour
 - Remote location, limited construction time, harsh conditions
 - Challenging logistics still completed in time/budget
 - Gained expertise and developed techniques to do it again
- Ice optical properties being studied thoroughly
 - Tilted layers that flow characterized
 - Still learning about what happened in the holes
 - Upgrade to be loaded with calibration devices to improve knowledge

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